



北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS

Tiansuan Constellation: An Open Research Platform

Shangguang Wang

Department of Computer Science

Beijing University of Posts and Telecommunications

www.sgwang.org

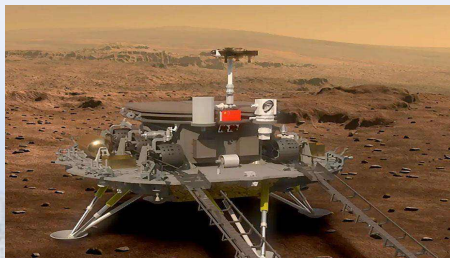
Background(1)



- The 80% of the world's land and 90% of the world's oceans are not covered by ground Internet
- The 50% of the world's population has difficulty accessing the Internet



- Disaster relief, emergency response, remote sensing and other applications lead to an urgent need for in-orbit satellite computing and in-orbit services



- With the intensification of competition among major powers, frequent disasters and exhaustion of resources, it is necessary to embark on interstellar voyages to expand the living space of mankind

Background(2)



- Satellite network has become a global hotspot such as Starlink, OneWeb, China Satellite Network and so on.

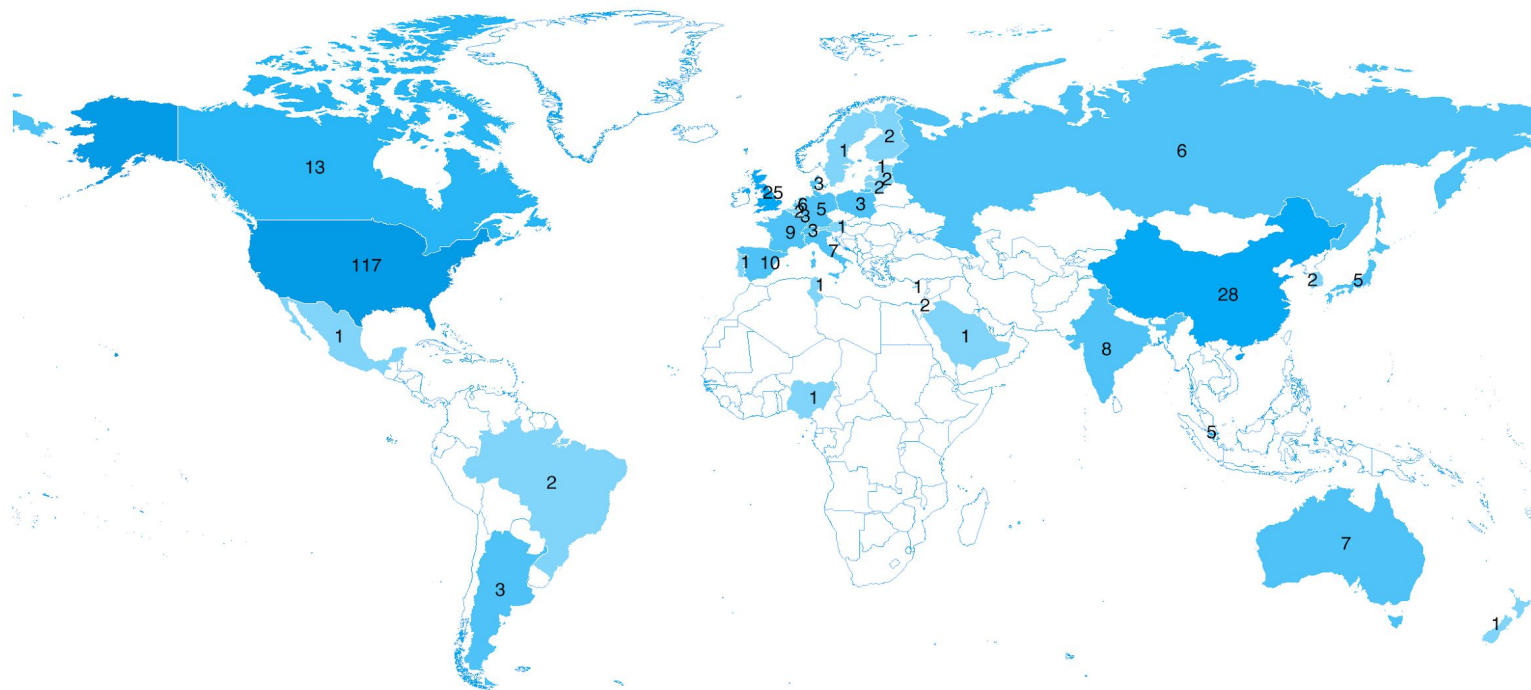


- Satellite communication is characterized by wide coverage, large communication capacity, low transmission delay, no geographical influence and advantages in global information broadcasting
- Based on the ground network and extending from the space network, it will elevate the human cyberspace to a new dimension

Background(3)



Constellations Headquarters World Map



Background(4)



- Bridge the research gap
- Contribute to the universal connectivity

The screenshot displays the ACM Digital Library website. The top navigation bar includes the ACM Digital Library logo, the Association for Computing Machinery (ACM) logo, and links for Browse, About, and Sign in. Below this is a secondary navigation bar with links for Journals, Magazines, Proceedings, Books, SIGs, Conferences, and People, along with a search bar labeled 'Search ACM Digital Library'. A third navigation bar contains links for Newsletter Home, Latest Issue, Archive, Authors, Affiliations, and Award Winners. The main content area shows the breadcrumb path: Home > SIGs > SIGCOMM > ACM SIGCOMM Computer Communication Review > Vol. 51, No. 2 > SatNetLab: a call to arms for the next global internet testbed. The article title 'SatNetLab: a call to arms for the next global internet testbed' is highlighted with a red box, with the label 'RESEARCH-ARTICLE' above it. Below the title are social media sharing icons for Twitter, LinkedIn, Weibo, Facebook, and Email. The author information is listed as 'Author: Ankit Singla' with a link to 'Authors Info & Claims'. At the bottom, the publication details are provided: 'ACM SIGCOMM Computer Communication Review, Volume 51, Issue 2 • April 2021 • pp 28–30 • https://doi.org/10.1145/3464994.3465000'.

ACM DIGITAL LIBRARY

Association for Computing Machinery

Browse About Sign in

Journals Magazines Proceedings Books SIGs Conferences People

Search ACM Digital Library

Newsletter Home Latest Issue Archive Authors Affiliations Award Winners

Home > SIGs > SIGCOMM > ACM SIGCOMM Computer Communication Review > Vol. 51, No. 2 > SatNetLab: a call to arms for the next global internet testbed

RESEARCH-ARTICLE

SatNetLab: a call to arms for the next global internet testbed

Twitter LinkedIn Weibo Facebook Email

Author: Ankit Singla [Authors Info & Claims](#)

ACM SIGCOMM Computer Communication Review, Volume 51, Issue 2 • April 2021 • pp 28–30 • <https://doi.org/10.1145/3464994.3465000>

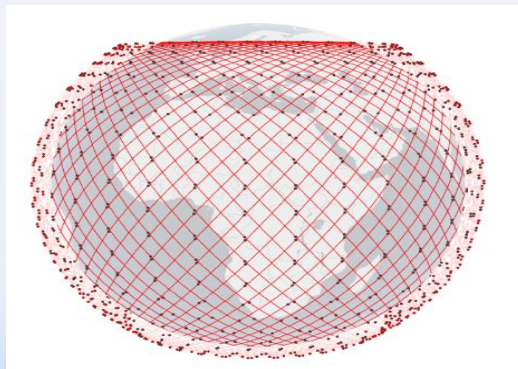
Our Vision



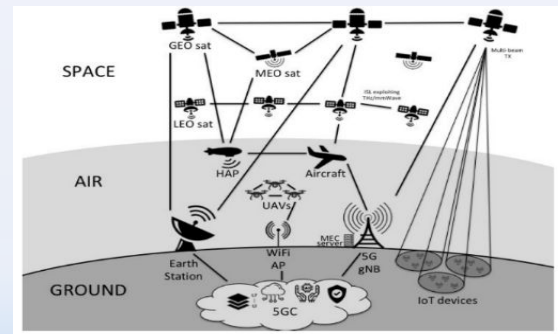
- Satellites are becoming the next-generation platform for communication and computing
 - After PCs, datacenters, smartphones, edges...
 - Investment on the ground is getting marginal return compared to space



Reduced Cost



Dense Satellite Mesh

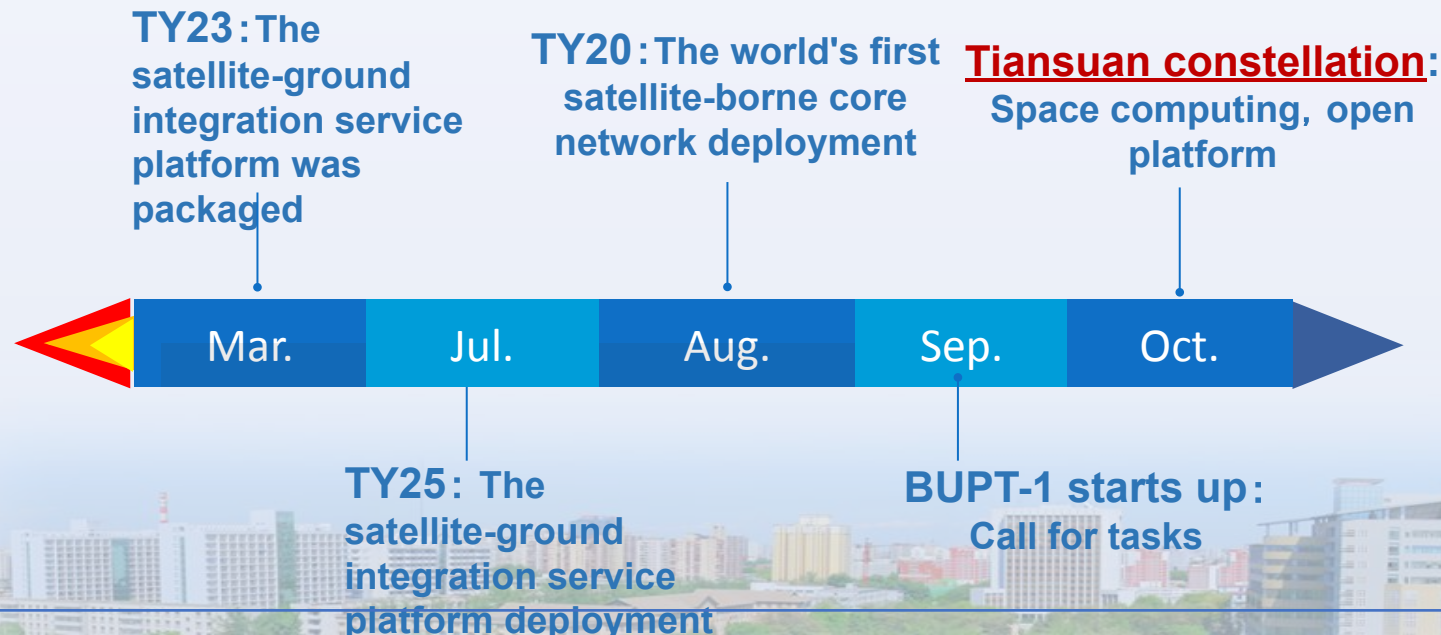


Satellite-terrestrial integrated network

Our Vision



- **SNIC LAB**: established in June 2020 at Shenzhen. Interested in interstellar civilization, interstellar networks, satellite networks, distributed AI computing, etc.
- **Tiansuan constellation (天算星座)**



Our Goal: Building an open research platform facing human needs, based on industry-university-research and application

Satellite

Smart

Servitization

Open

Computing

Meshing

Merging

Distributed

Key tasks

6G core networks

Internet of data

Operating system

Device testing

Edge Computing

Service opening

2023

Phase 1
accomplish

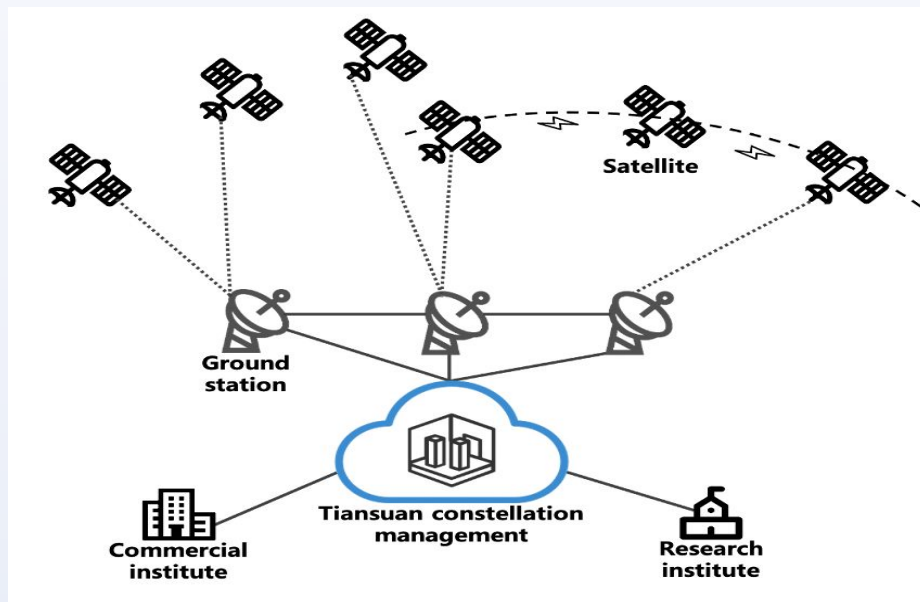
2022

First
satellite
launch

2021

Experimental
satellite
launch

Tiansuan (1)



Communication

Computing

Satellite operating system

Security and reliability

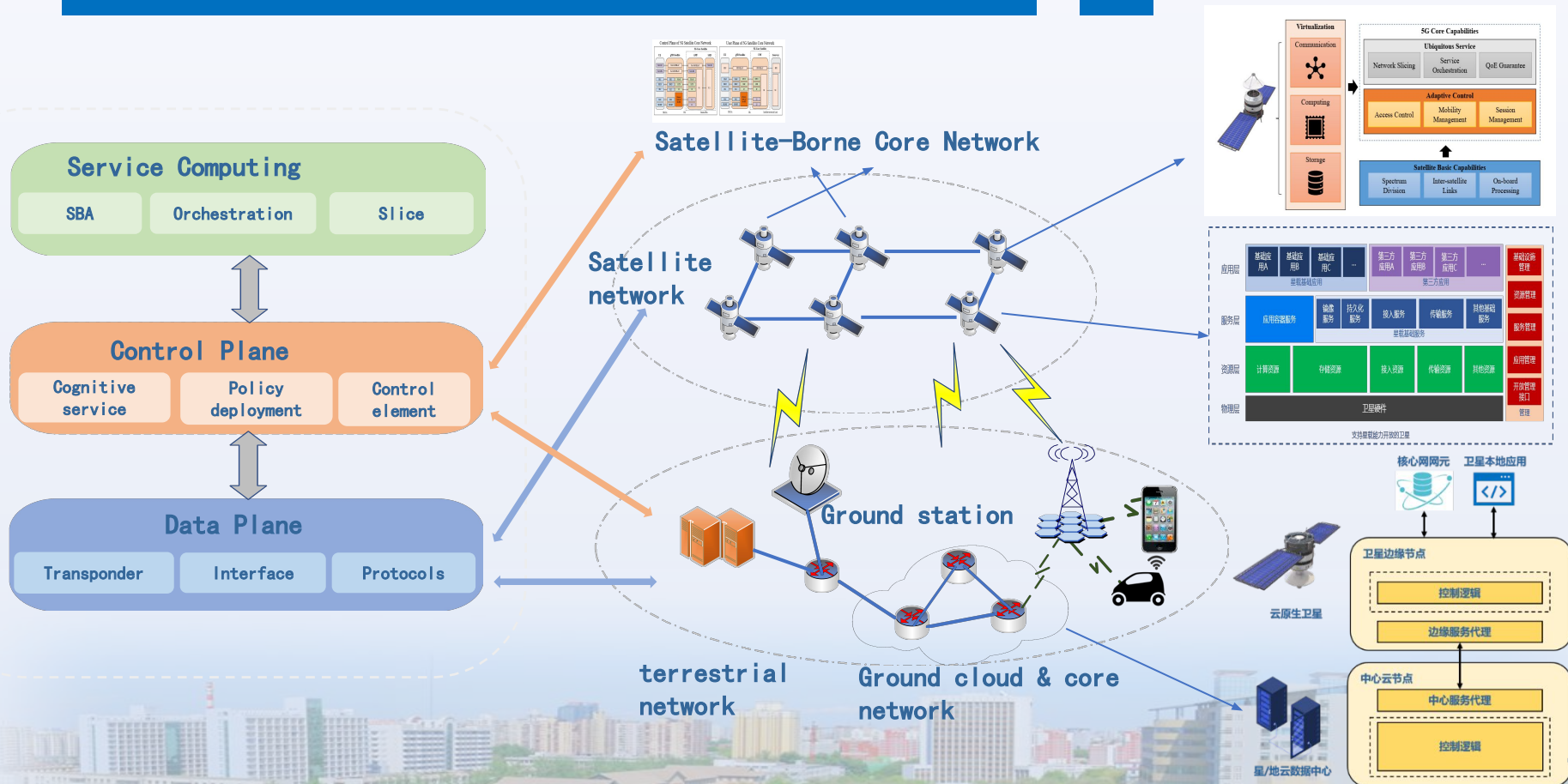
Hardware testing

Shangguang Wang, Qing Li, Mengwei Xu, Xiao Ma, Ao Zhou, Qibo Sun, Tiansuan Constellation: An Open Research Platform, Proc. IEEE EDGE 2021, Invited Paper.

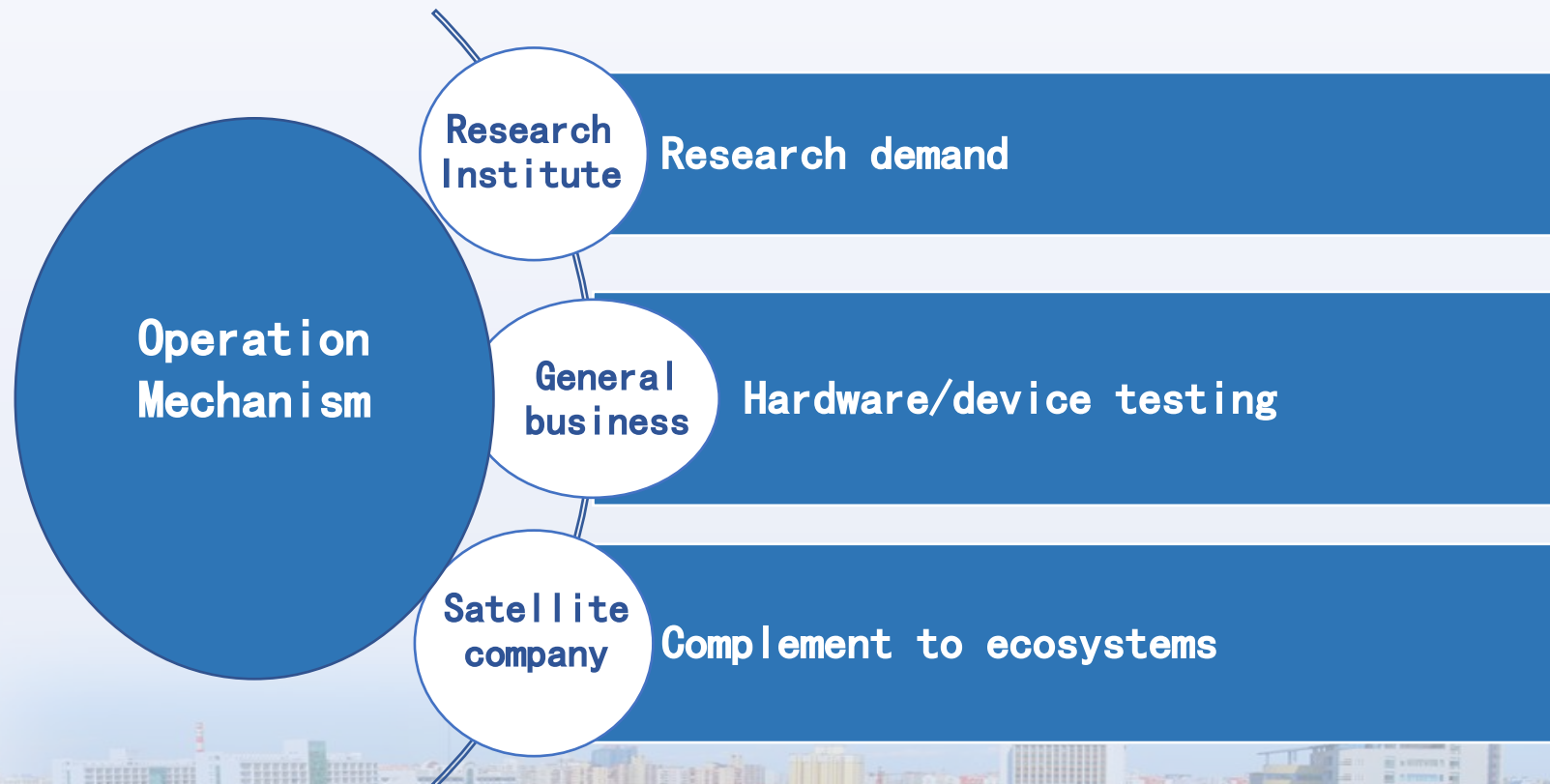
Tiansuan (2)



北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS



Tiansuan (3)



Tiansuan (4)



北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS

■ Tiansuan Experiment Platform v0.1

■ <https://github.com/TiansuanConstellation/TiansuanExperimentPlatform>

The screenshot shows the GitHub repository page for TiansuanExperimentPlatform. The page includes a README.md file with the following content:

Advantages

At present, Tiansuan Constellation has several satellites in orbit. We have established cooperative relations with numerous universities including Tsinghua, Peking, Beihang University and so on, and successfully carried many scientific research projects to the space.

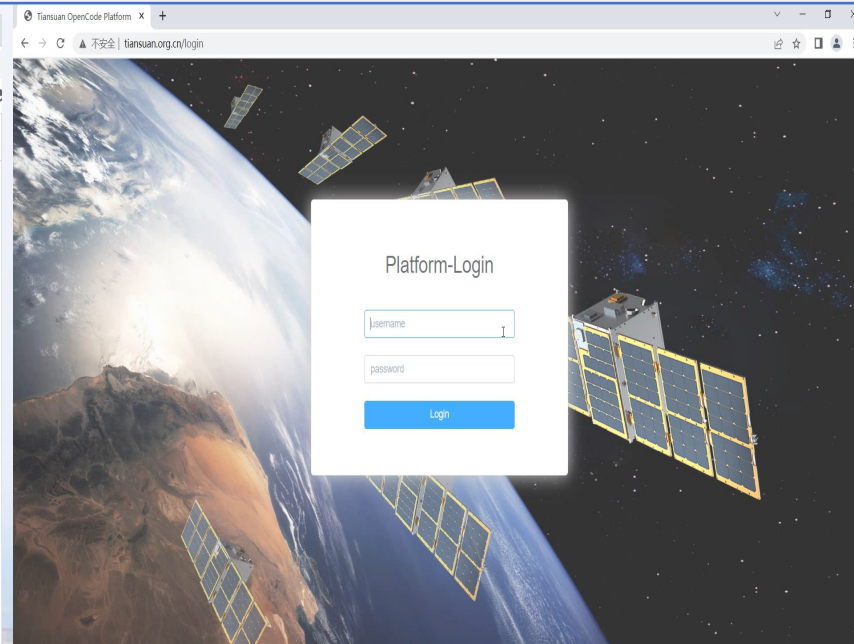
We provide unified hardware equipment, common access methods and strong technical support for the thoroughly customized in-orbit research and experimental needs.

Make Experiment Proposal

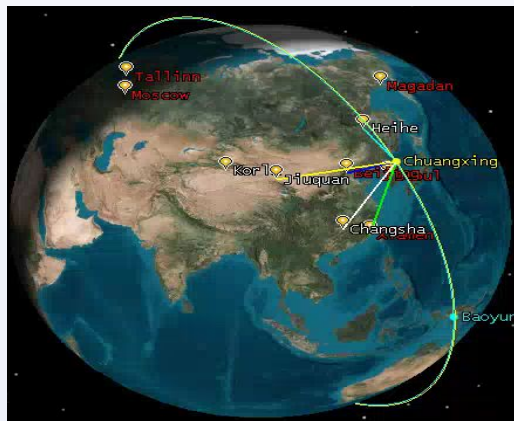
If you would like to conduct experiments, please visit [Tiansuan Experiment Platform v0.1](#). We welcome all the members to participate and push forward the research of in-orbit computing together.

At the same time, Tiansuan Constellation also welcomes individuals, organizations and institutions dedicated to satellite research to use our platform for in-orbit computing, research and experiments. If you want to use our platform, you can register an account and submit the project. If so, you need to follow the [User Agreement of Tiansuan Experiment Platform](#).

Copyright



Current work: Launch two satellites



- 5G Core Network with 5G gNB software
- Cognitive Service Architecture for 6G Core Network
- Cloud-native Satellite
- Quic Protocol
- Network measurement



2021. 12. 7
Tiansuan1 (baoyun)



2022. 02. 27
Tiansuan2 (innovation Raytheon)

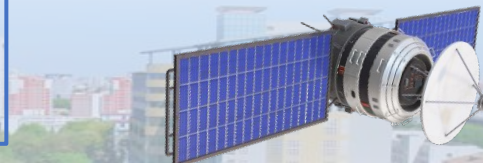
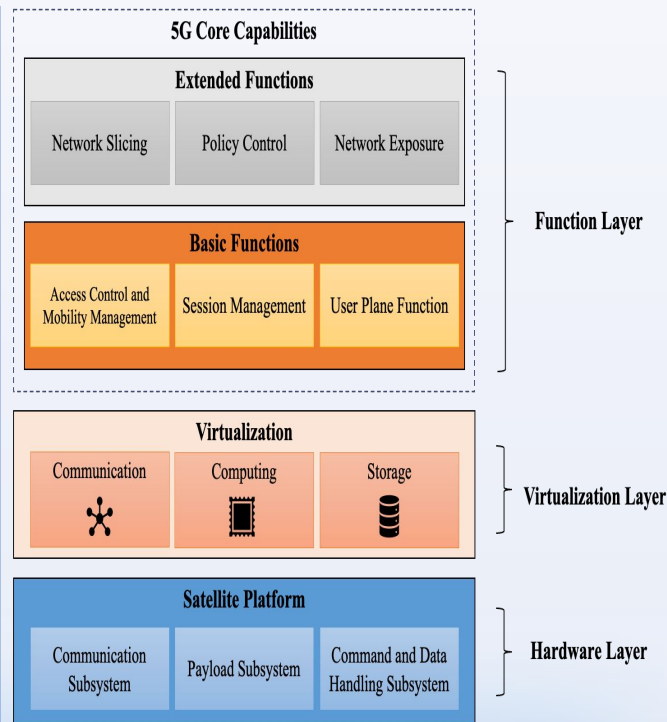


Case Study: Satellite 5G Core Network



■ Motivations

- It supports **LEO Satellites as Base Stations** and can integrate with future access networks which are made up of large-scale LEO satellite constellations
- It has **Potential Performance Gain**, and will reduce the control plane signaling interaction delay and speed up the user access procedures.
- It **benefits Onboard Services**, mobile users can access the satellite services more conveniently

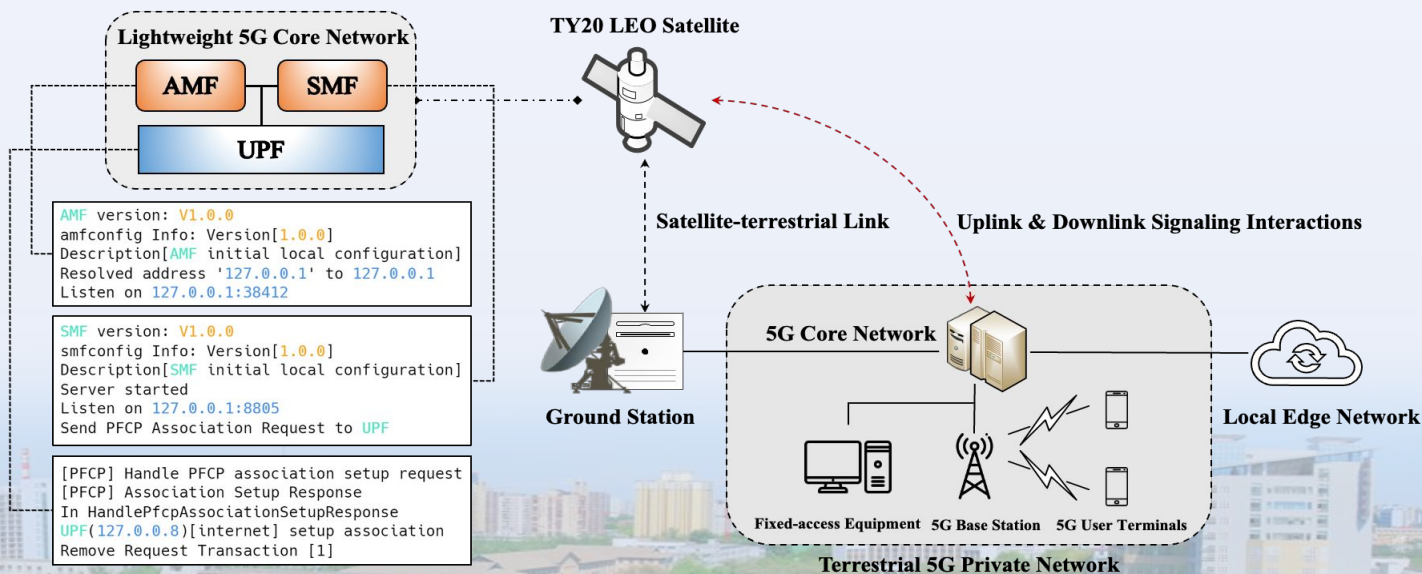


Case Study: Satellite 5G Core Network



■ Architecture

- It enables **Cloud-Native Networks in Space**, and build network functions like web apps
- It complements **Terrestrial 5G Networks**, and unites the Space-Ground network from a Mobile Network perspective



Case Study: Satellite 5G Core Network



北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS



Ruolin Xing, Xiao Ma, Ao Zhou, Schahram Dustdar, Shangguang Wang, From Earth to Space: A First Deployment of 5G Core Network on Satellite, China Communications, <https://arxiv.org/abs/2210.05405>

Case Study: cloud-native satellite



北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS

Huawei Cloud gets world's first

+

forum.huawei.com/enterprise/en/huawei-cloud-gets-world-s-first-cloud-native-satellite-with-sky-comp...

xin Gmail YouTube 地图 教师首页-欢迎访问... 外文资源-北京邮电... 深圳市科技业务管... 人选推荐工作系统 国家科学自然基金...

Huawei Enterprise Support Community

User Gu

HUAWEI

Community Forums Groups Blog & Collections Rewards FAQ Top Members Subscribe

Community > Forums > Cloud & Big Data > Huawei Cloud gets world's...

Huawei Cloud gets world's first cloud native satellite with sky computing constellation in space

Created: Jan 3, 2022 20:18:16 Latest reply: Feb 10, 2022 19:57:16 959 15 8 0 0

View the author 1#

Hi Everyone.
Greetings! 🙌 Happy New Year 🎉

World's first cloud-native satellite, equipped with the Sky Computing Constellation computing platform, successfully arrived and is working stably in orbit on December 10, according to Chinese media.

BAZ

L9

MVE

Author

343 3.0K

Follow Ch

Post

Recommended

https://forum.huawei.com/enterprise/en/profile/2837985?type=posts

19:37 2022/10/11

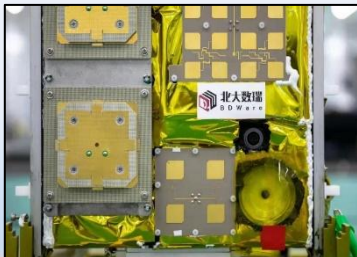
Case Study: DOI satellite node



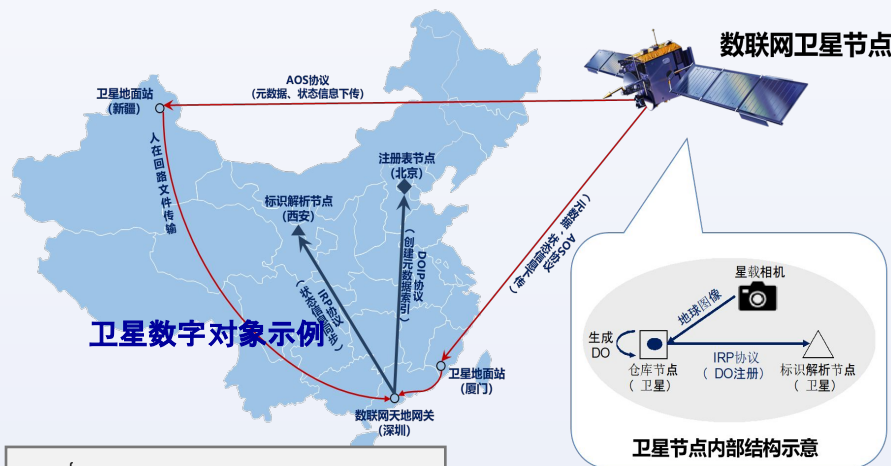
北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS



2021.12.7 Gushenxing1 Rocket



Data of Internet satellite node



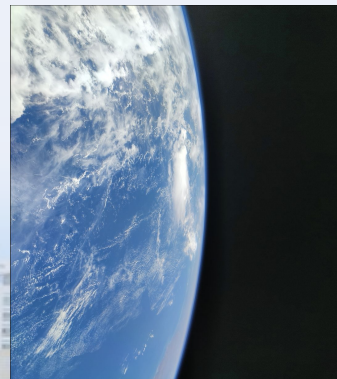
卫星数字对象示例

Marking

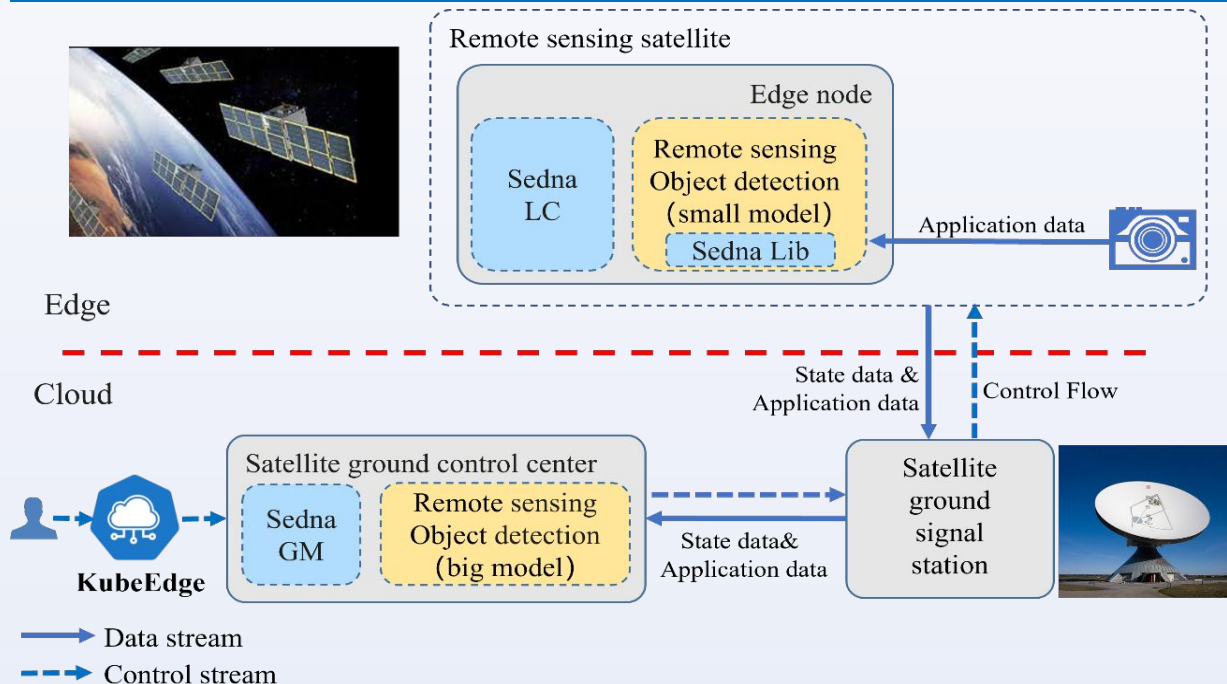
Metadata

Entity

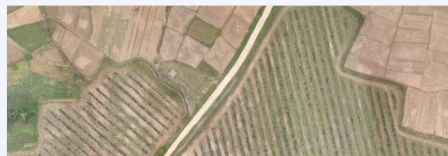
```
{
  "id": "86.5000.470/do.aSn44HqaO7_bdw",
  "type": "0.Type/DO",
  "attributes": {
    "name": "2wd89a41wd.jpg",
    "from": "satellite",
    "desc": "photos by xiaomi",
    "date": "20220301"
  },
  "elements": [
    {
      "attributes": {
        "size": "17.6MB",
        "format": "jpeg"
      },
      "data": {}
    }
  ]
}
```



Case Study: Satellite-ground computing



Accuracy rate	Recall rate
99.13%	99.07%



The benefits

- Improve the accuracy of area statistics ↗
- Reduce satellite energy consumption ↘
- Slow down the satellite-earth traffic ↘
- Reduce transmission costs ↘

- The cooperative AI inference between satellite and ground station is realized. In remote sensing scenarios, the identification accuracy of ground targets in orbit is improved by more than **50%** through in-orbit cloud detection.
- Through in-orbit calculation, the amount of data returned by the satellite is reduced by **90%**

Case Study: Satellite-ground computing

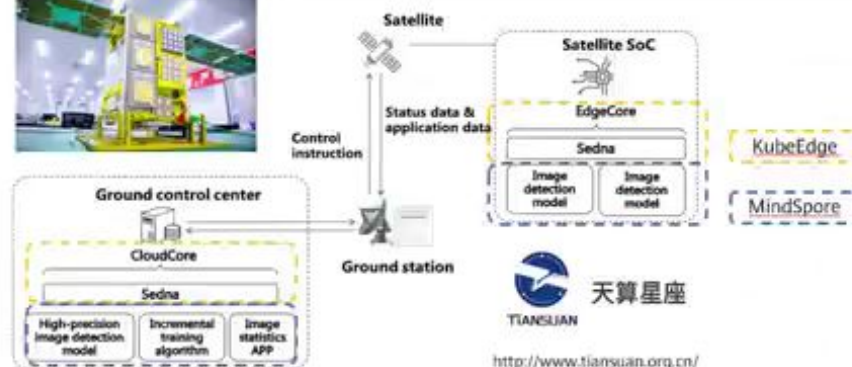


Huawei showed the work on the KubeCon and CloudNativeCon Europe 2022

Cloud Native + AI For Space



Number	Orbital Altitude	Mass	Battery Capacity	Spectrum	Uplink Rate	Downlink Rate	BSA	Processor
1	500~510km	< 30kg	1100Wh - 2300Wh	X-band	0.1Mbps - 1Mbps	10Mbps - 400Mbps	NO	CPU/DPU
2	500~510km	< 30kg	1100Wh - 2300Wh	X-band	0.1Mbps - 1Mbps	10Mbps - 400Mbps	NO	CPU/DPU
3	500~510km	< 30kg	1100Wh - 2300Wh	X-band	0.1Mbps - 1Mbps	10Mbps - 400Mbps	NO	CPU/DPU
4	> 500km	> 30kg	> 3000Wh	X, Ku, Ka bands	> 200Mbps	> 10Gbps	YES	GPU/NPU/DPU
5	> 500km	> 30kg	> 3000Wh	X, Ku, Ka bands	> 200Mbps	> 10Gbps	YES	GPU/NPU/DPU
6	> 500km	> 30kg	> 3000Wh	X, Ku, Ka bands	> 200Mbps	> 10Gbps	YES	GPU/NPU/DPU



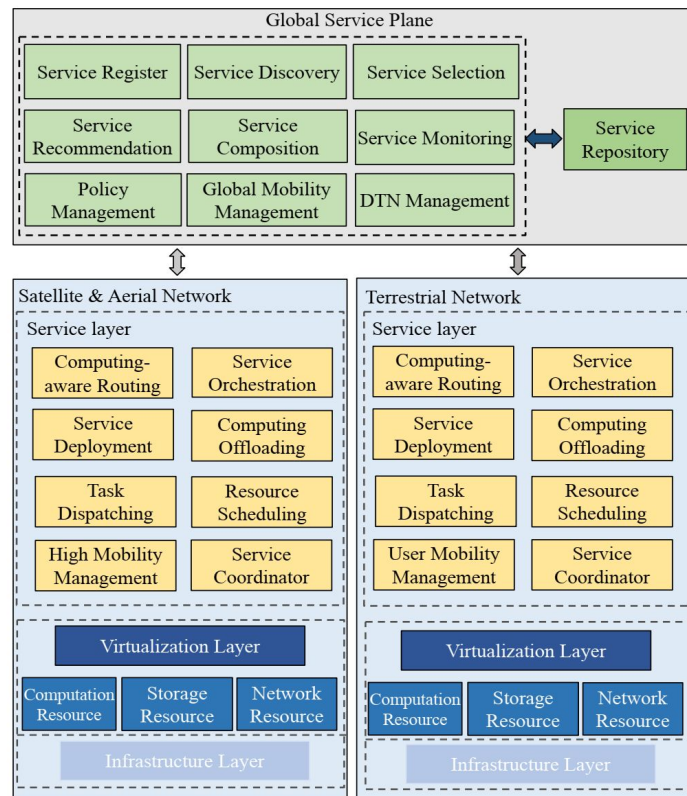
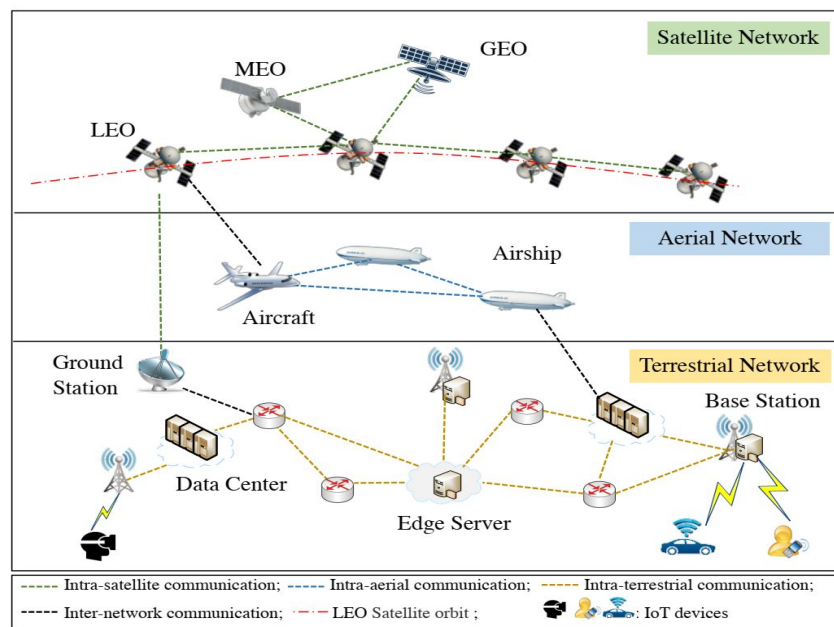
- Working with BUPT, PKU, CMCC on the **Tiansuan Constellation** with Tiansuan-1 launched in Sep 2021;
- Shipped with **CNCF KubeEdge** and **MindSpore** to address the challenges of :
 - ❖ On-orbit computation to minimize orbit-earth communication for better life span
 - ❖ Edge-cloud real time inference and Incremental deep learning for SAR type task

Case Study: Space service computing



Challenges:

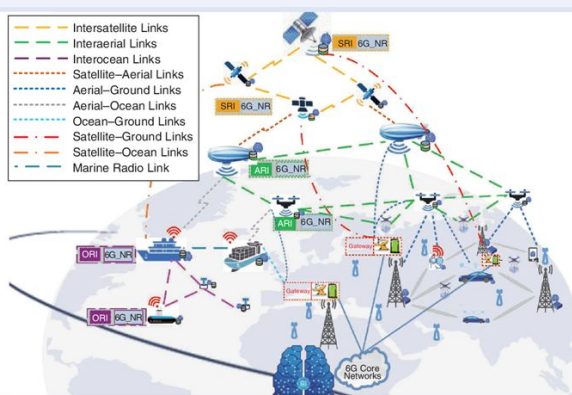
- ◆ Space-time regional restricted connectivity
- ◆ Multi-dimensional complexity of resources
- ◆ Diversified user needs





6G exploration (2023 –)

- 6G space edge core network
- Service continuity guarantee
- Space-air-ground deterministic latency guarantee
- Space-air-ground service offloading and coordination
- Security and reliability



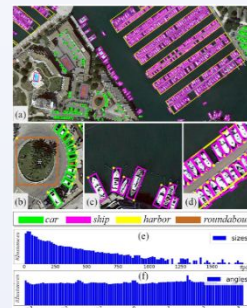
Research plan



北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS

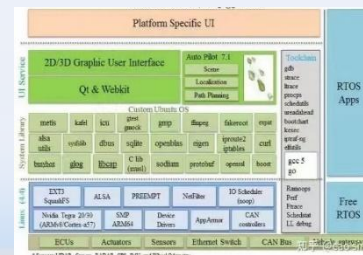
Satellite-distributed AI (2022 –)

- Space-ground coordinated prediction
- Cross-satellite federated learning for data privacy
- Hardware acceleration for resource-efficient ML



Satellite Operating System (2023 –)

- Better performance and security
- Dual-kernel (RTOS + Linux)
- Rust-based

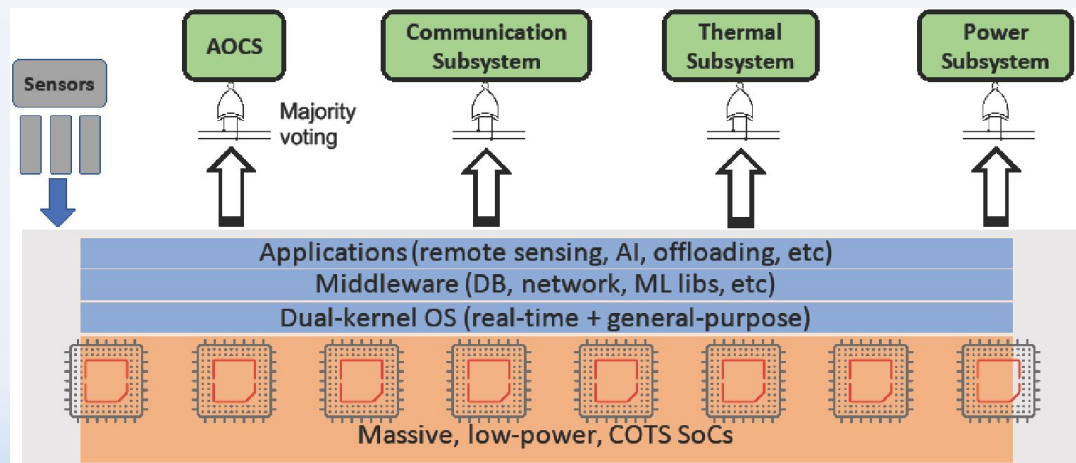


Research plan



In-space Computing Server (2022 –)

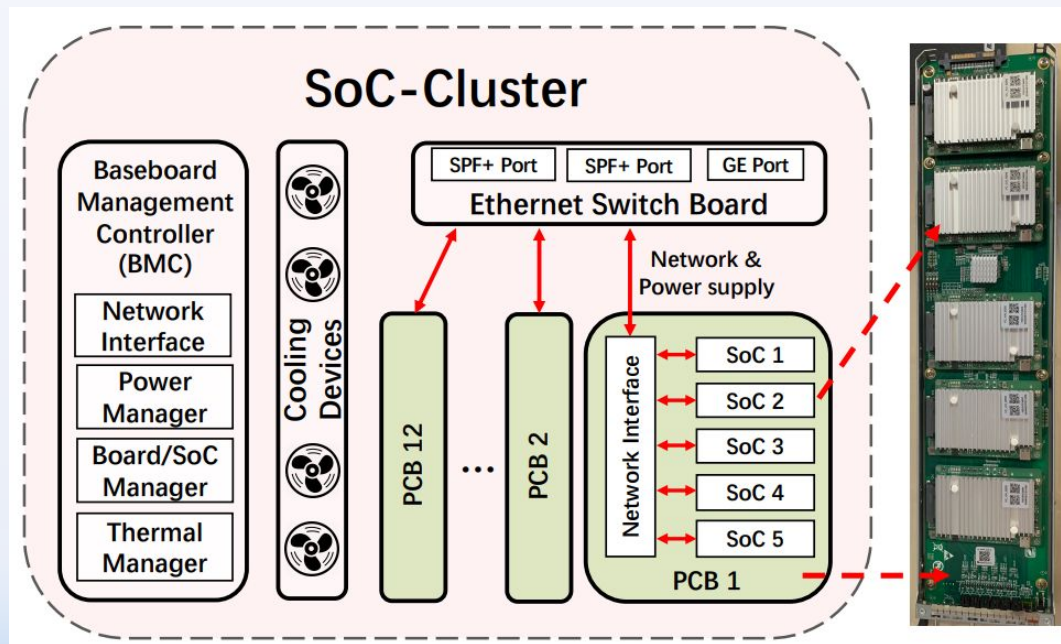
- A satellite-borne server design with massive ARM SoCs
- High computing density, high reliability, and high energy efficiency



Research plan



In-space Computing Server (2022 –)



Research plan

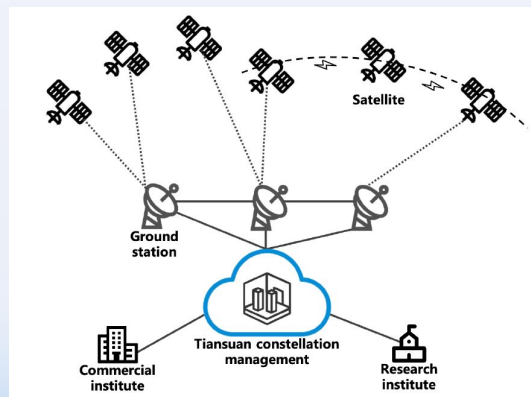


北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS



Open Platform (2022 –)

- A public, web-based, unified platform that provides services to third-party researchers and practitioners
- = Satellites + ground stations + super-computing data centers



Existing partners:

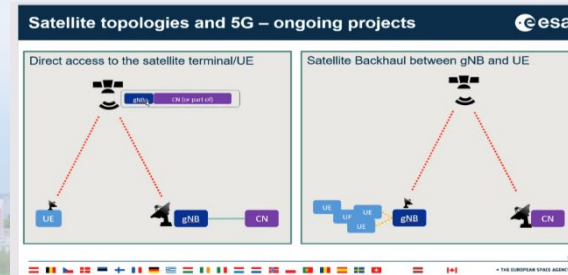
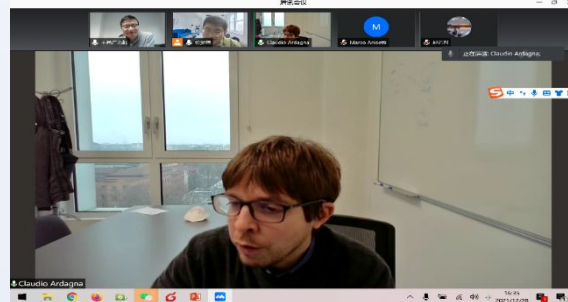
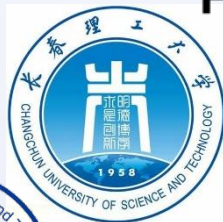
- University of Milan, Italy
- Vienna University of Technology, Austria
- Peking University, China
- Chinese Academy of Sciences, China
- etc...

The blueprint paper about Tiansuan Constellation: S. Wang, Q. Li, M. Xu, X. Ma, A. Zhou, Q. Sun, Tiansuan Constellation: An Open Research Platform, IEEE EDGE, 2022

International cooperation



北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS



International cooperation



北京邮电大学
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS

<http://ieee-satellite.org/>



CALL FOR PAPERS

IEEE Satellite 2022 will be held as a hybrid event. Authors may present their papers in person in Shenzhen or virtually. The conference is solely sponsored by the IEEE Computer Society under the auspice of the IEEE Technical Committee on Cloud Computing (TCCLD). IEEE Satellite aims to become a prime international forum for both researchers and industry practitioners to exchange the fundamental advances in the state of the art and practice of Satellite computing in the field of Computer Science and Electronic Engineering.

Authors are invited to submit the original papers via the EasyChair system: <https://easychair.org/my/conference?conf=satellite2022>. All submitted manuscripts will be peer-reviewed by at least three reviewers. IEEE Satellite will incorporate a **double-blind** review process. All papers must not include authors' names, or any other contents revealing authors' information.

Accepted papers will appear in the conference proceedings published by the IEEE Computer Society Press. **All accepted papers are allowed to deploy the studies on Tiansuan Constellation with no charge** (if the authors are interested).

Topics of Interest

Satellite computing architecture/platform, Satellite network, Satellite communication, Cloud-native satellite, Satellite operation system, Ground station system, Remote sensing, Earth observation, Solar energy, Satellite computing for smart city, Satellite computing for disaster rescue, Satellite and space system, Space surveillance and tracking, Autonomous systems and robotics for space, Space environment and protection, Vehicular network and system, Unmanned aerial vehicle system, 5/6G network and system, Edge network and system, Satellite security and privacy, AI for Satellite integrated system, Laser communication.

Conference Organizers

General Chairs
Shangguang Wang
Beijing University of Posts and Telecommunications
Abbas Jamali-pour
University of Sydney
TPC Chairs
Xiao Ma
Beijing University of Posts and Telecommunications
Wei Li
State Radio Spectrum Management Center
Important Dates
Full Paper Submission
June 15, 2022
Notification of Acceptance
August 15, 2022
Final Paper Submission
August 31, 2022



Detailed Information will be posted on the website:
<http://www.ieee-satellite.org>

<https://competition.huaweicloud.com>

Coding race on the satellite

华为云大赛 · 代码上太空 赛开始

奖金: ¥150,000

0 团队数	0 报名人数
-------	--------

立即报名

剩余19天9小时

赛程截止时间: 2022/07/30

赛事介绍

赛题详情

奖项配置

我的团队

提交作品

每一个开发者都了不起!

华为开发者大赛

Spark Infinity 创想无限

【大赛背景】

码上太空大赛聚焦在云原生、AI、卫星系统联合的全场景创新,面向广大开发者征集能适用于卫星的创新应用,入选作品将通过华为和北邮联合设计完成的“云原生卫星计算平台”部署到“天算星座”计划的多颗卫星中,实现“星海畅游”。活动旨在促进广大开发者充分运用华为云原生、AI等工具和能力,创造性开发,加速卫星计算智能化流程,产学研携手共同构建智能化的云原生卫星应用解决方案,帮助卫星更好地服务于应急通讯、生态监测、防灾减灾、城市建设。

【参赛对象】

具备应用软件开发能力的组织、企业或个人、学生等;
*企业用户需完成企业认证, [点击此处完成认证](#)。

【赛程说明】

Future work



- Launch Tiansun3 (望齐州号), 2022. 11. 6
- Launch BUPT1 (北邮一号), 2022. 12. 10
- Launch other 2 satellite, about 2023. 2

A web-based, easy-to-use platform that allows any registered users to submit their code directly to real satellites!



- Introduce an open research platform, Tiansuan constellation
- Present the goal and key design and state how various institutes can benefit
- Discuss many potential research topics
- Give several case studies

Thanks



Thanks & Questions!

Shangguang Wang

<http://www.tiansuan.org.cn/>